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SUBMITTED BY:

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**(NASA-CR-196543) FIELD AND DATA
ANALYSIS STUDIES RELATED TO THE
ATMOSPHERIC ENVIRONMENT Final
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INTRODUCTION

The title of this contract was "Field and Data Analysis Studies Related to the Atmospheric Environment." It covered work on a broad array of projects from defining new sensor concepts for possible use in orbit to making detailed electric field measurements for revision of space shuttle launch commit criteria. The work performed and the resulting publications and reports are best described by those who did the work (below).

Dr. Stanley Kidder - SUMMARY OF WORK

My primary scientific effort was on Task 1 of the contract. I worked with MSFC personnel toward development of the Geostationary Earth Observatory (GEO) to complement the Earth Observing System. I also worked on an independent idea for a new satellite in Molniya orbit, which would act as a high-latitude geostationary satellite.

In addition, I supervised all of the work described below.

Publications

Kidder, S. Q., 1992: Applications of a meteorological/oceanographic satellite in Molniya orbit. *Preprints: Sixth Conference on Satellite Meteorology and Oceanography*, American Meteorological Society, Boston, 411-414.

Kidder, S. Q., 1992: On the use of satellites in Molniya orbit for meteorological and oceanographic observations of the high latitudes. *Offprints: 43rd Congress of the International Astronautical Federation*, Paris, France, Paper No. IAF-92-0091.

Travel

8-10 January 1992: Atlanta, Georgia, to present paper titled "Applications of a Meteorological/Oceanographic Satellite in Molniya Orbit" at the Sixth Conference on Satellite Meteorology and Oceanography of the American Meteorological Society.

31 August - 4 September 1992: Washington, DC, to present paper titled "On the Use of Satellites in Molniya Orbit for Meteorological and Oceanographic Observations of the High Latitudes" at the World Space Congress.

Dr. Douglas Mach - SUMMARY OF WORK

AirBorne Field Mill (ABFM) Project

My major project during this contract period was the ABFM program. The goal of the project is to improve the current set of NASA/Air Force lightning related Launch Commit Criteria (LCC) rules. We were to study marginal storm conditions in and around the KSC area with an instrumented high performance jet aircraft. In our case the aircraft was a NASA Lear 28.

My responsibilities within this project included overseeing the design and construction of a set of rotating vane field mills, telemetry system, and other instrumentation that were installed on the Lear 28. I was also responsible for the ground station software and hardware that was to be used to both direct the aircraft and assist in the analysis of the data after the deployments. Other responsibilities included insuring that all data measured on the aircraft were transmitted to a ground station.

We completed two summer and two winter deployments in Florida. The last summer deployment was during and coordinated with the Convective and Precipitation Electrification (CaPE) Experiment. The deployments in the summer and winter were done so that we could study both weather regimes that are common in the KSC area.

The analysis was done under very tight deadlines. The analysis of each deployment had to be completed within six months of the end of the deployment. I was the primary scientist for the analysis of the data. I was able to complete the analyses within the allotted time frames. I completed 4 large (over 100 pages each) documents describing the data and our analysis. The four documents are:

- a. ABFM Operational Analysis Document for the 1990 Summer Deployment (July 6, 1990 to August 22, 1990)
- b. ABFM Operational Analysis Document for the 1991 Winter Deployment (February 14, 1991 to March 18, 1991)

- c. ABFM Operational Analysis Document for the 1991 Summer Deployment (July 5, 1991 to August 26, 1991)
- d. ABFM Operational Analysis Document for the 1992 Winter Deployment (January 16, 1992 to March 8, 1992)

We formulated new Launch Commit Criteria based on our data and analysis that are currently being reviewed by the ABFM LCC Committee, NASA, and the Air Force. The results of our analysis should result in safer LCC rules that also permit more launch opportunities.

Cylindrical Field Mill

I also continued work on my Center Director Discretionary Fund (CDDF) Proposal. The proposal was for the designing, building, testing, and deployment of a set of cylindrical field mills for aircraft use. The mills were to have automatic aircraft charge nulling. The project was put on hold by the ABFM program.

Publications

Douglas M. Mach and W. David Rust, Two-Dimensional Velocity, Optical Risetime, and Peak Current Estimates for Natural Positive Lightning Return Strokes, J. Geophys. Res., 98, 2635-2638, 1993.

Presentations

- D. M. Mach, J. C. Bailey, and H. J. Christian, Electrification of Stratiform Winter Clouds Near The Kennedy Space Center, Florida.
- J. C. Bailey, D. M. Mach, and H. J. Christian, Summary of the NASA Learjet Data During the 1991 CaPE Experiment at the 1991 Fall AGU Meeting in San Francisco, California, December 9-13, 1991.

Travel

- January 20-24, 1991: Hampton, VA to test the ABFM telemetry system at NASA Langley Research Center.
- May 1-5, 1991: Palo Alto, CA to attend ABFM Data Analysis and Calibration Report discussion (part one) at Stanford Research Institute.
- June 3-5, 1991 to take part in the ABFM High Voltage Unit Test at NASA/LaRC in Hampton, VA.
- July 12-14, 1991 to solve crisis with the ABFM ground station software package during the summer 1991 deployment at NASA/KSC at Kennedy Space Center, FL.
- December 9-13, 1991: San Francisco, CA to attend Fall AGU meeting and present most recent results of the ABFM project.

Mr. Jeff Bailey - SUMMARY OF WORK

The NASA Airborne Field Mill Project (ABFM) was the primary focus of my work throughout the contract period. The ABFM project studied marginal electrification storm conditions, in relationship to the current Launch Commit Criteria (LCC) at KSC for the shuttle and various other launch vehicles, with an instrumented high performance Lear 28/29 aircraft. I filled the role of the field scientist in charge of operations during all field deployments to KSC. I was responsible for the preparation for each field deployment and for maintenance and operation of equipment. Back at MSFC, I was responsible for the calibration of the field mill system. I assisted with data analysis and writing of the required reports (see list above under Doug Mach) and helped recommended LCC rule changes. I worked closely with Doug Mach on this project.

In addition to the ABFM, the last part of the contract period was spent in support of the DC-8 and ER-2 Lightning Instrumentation Packages (LIP) as part of both the Tropical Ocean - Global Atmosphere / Coupled Ocean-Atmospheric Response Experiment (TOGA/COARE) deployment to Townsville, Australia and the Convective and Moisture Experiment (CAMEX) to Wallops Island, VA. I took the lead in developing and installing LIP on the DC-8 aircraft. I was also responsible for data taking and equipment maintenance while in Townsville for the DC-8 LIP. I was responsible for the ER-2 LIP system for CAMEX.

Small amounts of time were spent on various other projects such as Advanced Ground Based Field Mill Network (AGBFM), Lightning Imaging Sensor (LIS), and Optical Transient Detector (OTD).

Publications

- Anderson, R. V. and J. C. Bailey, Errors in the Gerdien Measurement of Atmospheric Electric Conductivity, *Meteorol. Atmos. Phys.*, vol. 46, pp. 101-112, 1991.
- Koshak, W. J., J. C. Bailey, and H. J. Christian, A Direct Method for Calibrating Aircraft Electric Field Mill Systems, submitted to JGR, Jan, 1993.

Internal Reports

- Bailey, J., D. M. Mach, W. Koshak, and H. J. Christian, In Flight Vector Calibration of Shutter Type Field Mills Aboard a Lear 28/29 Aircraft.

Presentations

- Bailey, J., D. M. Mach, and H. J. Christian, Summary of the NASA Learjet Data During the 1991 CaPE Experiment, At the Fall 1991 AGU meeting in San Francisco, CA December 1991.
- Mach, D. M., J. C. Bailey, and H. J. Christian, Electrification of Stratiform Winter Clouds Near the Kennedy Space Center, Florida, At the Fall 1991 AGU meeting in San Francisco, CA, December 1991.
- Mach, D. M., J. C. Bailey, and H. J. Christian, Early Electrification of Convective Clouds near the Kennedy Space Center, Florida, At the Fall 1992 AGU meeting in San Francisco, CA, December 1992.
- Koshak, W. J., J. C. Bailey, and H. J. Christian, Calibration of Aircraft Electric Field Mill systems and Retrieval of Ambient Field, At the Fall 1992 AGU meeting in San Francisco, CA, December 1992.
- Christian, H., D. M. Mach, and J.C. Bailey, The Airborne Field Mill Project: A Project Summary, At the Fall 1993 AGU meeting in San Francisco, CA, December, 1993.
- Zipser, E., G. R. McGaughey, H. J. Christian, R. J. Blakeslee, J. Bailey, and D. P. Jorgensen, Electric Field and Passive Microwave Data Combined with Doppler Radar Data for the TOGA-COARE Squall Line of 22 Feb 1993, At the Fall 1993 AGU meeting in San Francisco, CA, December 1993.
- Blakeslee, R., J. Bailey, and H. Christian, Aircraft Investigations fo Lightning and Thunderstorms during TOGA-COARE, At the AMS meeting in Nashville, TN, January, 1994.

Travel

- 21 February - 11 March 1991: Kennedy Space Center, Florida, to be field scientist for the Winter 1991 ABFM deployment.
- 13-16 May 1991: Los Angeles, California, to attend ABFM Data Analysis and Calibration Report discussion (part two) at the Air Force Space Systems Division Headquarters, Los Angeles Air Force Base.
- 4-29 July 1991: Kennedy Space Center for first part of summer ABFM/CaPE deployment.
- 4 August - 1 September 1991: Kennedy Space Center for second part of summer ABFM/CaPE deployment.
- 8-13 December, 1991: San Francisco, CA, to present paper at Fall AGU meeting.
- 8 January - 5 February 1992: Kennedy Space Center for second winter ABFM deployment.
- 15 - 22 November 1992: Start integration for TOGA COARE project at NASA/Ames at Moffet Field, CA.
- 06 - 20 December 1992: Finish integration for TOGA COARE project at NASA/Ames. Also attend 1992 Fall American Geophysical Union Meeting in San Francisco, CA.
- 28 December 1992 - 22 February 1993: Participate in Calibration Flights at NASA/Ames Deployment to Townsville, Australia for TOGA COARE experiment
- 02 - 08 August 1993: Attend 1st TOGA COARE Data Workshop in San Diego, CA.
- 12 September - 8 October 1993: Deployment to Wallops Island, VA for CAMEX project.

Mr. Michael Stewart - SUMMARY OF WORK

Ground-Based Field Mill

The NASA Advanced Ground-Based Field Mill(AGBFM) program was the primary focus of my effort during the contract period. For this program I produced preliminary and final designs of the electronic circuitry and microprocessor firmware for the instrument. The preliminary designs were presented at a final design review held at NASA/Marshall Space Flight Center, with representatives

from the Air Force and NASA/Kennedy Space Center attending. An Interface Control Document was written to specify the interface between the AGBFM instrument and a central control and data collection computer. I also specified the design for, and supervised the implementation of, a semi-automated test and calibration facility for the instruments. The final assembly, test, and calibration of 35 instruments was also under my supervision.

In addition to the AGBFM program, I participated in the preparations and deployment of the CAPE field program, and in the preparations for the Pacific Exploratory Mission-WEST field program. This involved the testing and calibration of instruments for aircraft-based measurements of atmospheric electrical phenomena.

Mr. Dave Slaton - SUMMARY OF WORK

Work on this contract centered on designing, building, installing and testing electronic and computer equipment and software associated with atmospheric electricity measurements. The AirBorne Field Mill (ABFM), the Advanced Ground Based Field Mill (AGBFM), and the Lightning Instrument Package (LIP) were some of the projects. The bulk of the work was performed at MSFC, but part was performed at Ames Research Center, and part at Townsville, Australia, as part of TOGA-COARE.

Travel

21 August - 5 September 1991: Ames Research Center to take part in PEM-West Integration on NASA DC8 aircraft.

25 January - 9 March 1993: Townsville, Australia, to serve as field engineer for the MSFC Lightning Instrument Package in TOGA-COARE.

Mr. Dennis Buechler - SUMMARY OF WORK

Lightning Imaging Sensor Simulations

Experiments were performed on simulating observations from a Lightning Imaging Sensor (LIS) aboard the Tropical Rainfall Measuring Mission (TRMM) satellite. The focus of the research was on examining the monthly sampling error due to the somewhat irregular intervals that the instrument will observe an area on earth. A six year data base of cloud-to-ground lightning measurements from the Marshall Space Flight detection network was used in the study. A $30^{\circ} \times 30^{\circ}$ area centered on the lightning detection network was chosen as the target area for the 500 simulated orbits (randomly started at different locations) based on the TRMM orbital characteristics. For each of the simulations, the monthly LIS retrieved value (scaled to a full month) was compared to the actual lightning occurring during the month to obtain a root mean square error. The sampling error was then computed as the ratio of the rms error divided by the actual monthly lightning. The results show a sampling error of >100% for months with low lightning activity (about 0-2000 flashes per month). During high lightning months (>75000 flashes per month), the sampling error is about 28%. Since only cloud-to-ground lightning data were used in this study, the higher values obtained by including intracloud lightning (LIS will observe both cloud-to-ground and intracloud) are expected to further reduce the sampling error.

Presentations

Buechler, D.E. and R.J. Blakeslee, 1992: Cloud-to-ground lightning observations used to simulate observations from a low earth orbiting lightning sensor, *Preprints, 9th International Conference on Atmospheric Electricity*, St. Petersburg, Russia, June 15-19, 1992. (presentation by Hugh Christian)

Buechler, D.E., R.J. Blakeslee, and H.J. Christian, 1992: Simulating Lightning Imaging Sensor (LIS) observations from Tropical Rainfall Measuring Mission (TRMM) orbit, *EOS Trans. AGU*, 73(43), Fall Meeting Suppl., 115.

Dr. Mike Botts - SUMMARY OF WORK

Most of the activities of Botts and Phillips involved assisting ESAD scientists in meeting their scientific visualization and computing needs. Although these responsibilities involved many small tasks, they also included several more major efforts, including software development, participation in the EOS Scientific Computing Facility (SCF) Working Group, and visualization lab system support.

Visualization Development

Botts and Phillips have developed the initial Multidimensional Analysis of Sensor Systems (MASS) prototype for visualizing co-registered data from airborne flights, ground-based field mills, satellite imagery, volumetric radar data, and McIDAS geographical boundary data. Dr. Doug Mach (UAH), Pat Wright (USRA), and Dr. Kevin Knupp (UAH) provided fifteen minutes of CaPE airborne field mill, ground-based field mill, and radar data acquired on 16 March 1991. Anthony Guillory (NASA) provided color McIDAS satellite imagery of the east central Florida area. The prototype, written on the Silicon Graphics (SGI) using the Graphics Library (GL), proved the feasibility of real-time graphical interaction with these data types.

The prototype proved the feasibility of coregistering and viewing several distinct data sets within a single window, and providing the researcher with the ability to interactively alter the view and appearance of this data. The graphical techniques including line and surface rendering, display of irregularly spaced ground-based field mill data, texture mapping of images on a plane, and volume rendering of 3D radar data. In addition to developing the prototype, much initial detail has been given to the tentative structure and layout of the application. While expandability of both visual and analytical are a goal for the application, a major consideration is the development of an interface that is simple and intuitive for a scientist to use.

Another prototype visualization tool was developed for Dr. Roy Spencer to visualize 13 years of MSU global daily temperature anomaly data. This tool allowed a year's worth of data to be color coded, animated, and wrapped around a 3D globe which could be rotated for viewing different areas.

In addition, a high-quality four minute video was created showing unique features of the Molniya orbit and included a realistic satellite view of the Earth as the satellite approached and receded from the Earth. The video was presented at the 1992 AMS conference by Dr. Kidder.

Scientific Computing Facility (SCF) Working Group

Dr. Botts served as chairman of the EOS SCF Working Group at MSFC, established to determine the best means for meeting the computing requirements of 5 SCFs at MSFC. The final report, written primarily by Dr. Botts and Phillips, was published as a NASA TM #4392, entitled "Functional Requirements Document for the EOSDIS Scientific Computing Facilities of the NASA/MSFC Earth Science and Applications Division, 1992," and established many of the guidelines for computing facilities throughout the entire division (Botts et al, 1992).

Visualization Lab Support

Botts and Phillips both served in system support and testing capacities within the Visualization lab at MSFC. This involved computer system administration, user support, and hardware and software testing. The activities established the criteria for purchase of several Silicon Graphics (SGI) workstations for scientific computing, and initiated the successful use by scientists of several visualization software applications, including LinkWinds, AVS, and Explorer.

Publications

Botts, M., R. Phillips, J. Parker, and P. Wright, 1992: Functional Requirements Document for the Earth Observing System Data and Information System (EOSDIS) Scientific Computing Facilities (SCF) of the NASA/MSFC Earth Science and Application Division, NASA TM 4392, pp. 101.
Phillips, R. and M. Botts, 1991: Computer Industry Directions. VisTech, Issue 1.

Presentations

Botts, M., 1992: Visualization for Atmospheric and Global Change Research at the NASA Marshall Space Flight Center, IEEE Visualization '92, October 22, 1992.
Botts, M., 1992: Defining and Satisfying the Computing Requirements of the Scientific Computing Facilities at NASA/MSFC, AIAA Space Programs & Technology Conference, March 23, 1992.

Ms. Laurie Collins - SUMMARY OF WORK

Scientific Meeting Planning and Coordination

Several Science Team Meetings were held to integrate input from scientific investigators for the Lightning Imaging Sensor (LIS) and the Laser Atmospheric Wind Sounder (LAWS). I planned, coordinated and provided administrative support for the LIS and LAWS meetings listed below:

LIS Science Working Group Meeting, Guerneville, CA, December 6th - 9th, 1991

LAWS Science Team Meeting, Aspen, Colorado July 15th - 17th, 1991

LAWS Science Team Executive Meeting, Huntsville, Alabama December 12th, 1991

LAWS Science Team Meeting, Huntsville, Alabama, January 28th - 30th, 1992

LAWS Science Team Meeting, Falmouth, Massachusetts, July 28th - 30th, 1992